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THE PRE-CAMBRIAN ROCKS OF THE ALPS.¹

BY T. STERRY HUNT, LL.D, F.R.S.

THE writer began by reviewing the history of Alpine geology, and noticed first that speculative period when the crystalline rocks of the Alps, including gneisses, hornblendic and micaceous schists, euphotides, serpentines, etc., were looked upon as altered sedimentary strata of Carboniferous or more recent times. He then traced the steps by which these views have been discarded, and more and more of the rocks shown to belong to Eozoic or pre-Cambrian ages. In this connection the labors of von Hauer, Gerlach, Heim, Favre, Renevier, Lory, Gastaldi and others were analyzed, and reference was made to the great progress since the writer, in 1872, published a review of Favre on the geology of the Alps.

The sections by Neri, Gerlach and Gastaldi in the Western, and those of von Hauer in the Eastern Alps were described, and it was shown that all these agree in establishing in the crystalline rocks four great divisions in ascending order: 1st. The older granitoid gneiss with crystalline limestones, graphite, etc., referred by Gastaldi to the Laurentian. 2d. The so-called *pietre verdi*, or greenstone group, consisting chiefly of dioritic, chloritic, steatitic and epidotic rocks, with euphotides and serpentines, including also talcose gneisses, limestones and dolomites, and regarded by Gastaldi as Huronian. 3d. The so-called recent gneisses of von Hauer and Gastaldi, interstratified with and passing into granulites and micaceous and hornblendic schists, also with serpentines and crystalline limestones. 4th. The series of argillites and soft glossy schists with quartzites and detrital sandstones, including

¹ Read at the Minneapolis meeting of Amer. Assoc. Adv. of Science, Aug., 1883.

also beds of serpentine with talc, gypsum, karstenite, dolomite and much crystalline limestone. This fourth series, well seen at the Mont Cenis tunnel, is still claimed by Lory and some others as altered trias, but the present writer's view, put forth in 1872, that it is, like the preceding groups, of eozoic age, was subsequently accepted by Favre, and by Gastaldi, and is now established by many observations. To this horizon belong the crystalline limestones of the Apuan Alps, including the marbles of Carrara.

The writer next recalls the fact that he, in 1870, insisted upon the existence of a younger series of gneisses in North America, alike in the Atlantic States, in Ontario, and to the north-west of Lake Superior. These, in his address before the American Association for the Advancement of Science in 1871, he farther described under the name of the White Mountain series, and subsequently in the same year, called them Montalban. These rocks were then declared to be younger than the Huronian, and to overlie it, though in the absence of this latter it was pointed out that in Ontario and in Newfoundland the Montalban reposes unconformably upon the Laurentian. When these newer gneisses and mica-schists were first described in 1870, there was included with them an overlying group of argillites, quartzites and crystalline limestones, and for the whole the name of Terranovan was suggested provisionally; but in defining in the following year the White Mountain series, this upper group was omitted, and was subsequently referred to the Taconian series, the Lower Taconic of Emmons, and the so-called altered Primal and Auroral of H. D. Rogers, in Eastern Pennsylvania.

The writer next described his own observations in the Alps and the Apennines in 1881. He affirms the correctness of Gastaldi in referring the groups one and two to Laurentian and Huronian, finds the third, or the younger gneiss and mica-schist group of the Alps, indistinguishable from the Montalban, and regards the fourth as the representative of the American Taconian. It was maintained by Gastaldi that these pre-Cambrian groups of the Alps underlie directly the newer rocks of Northern and Central Italy, forming the skeleton of the Apennines, reappearing in Calabria, and moreover protruding in various localities in Liguria, Tuscany and elsewhere. The serpentines, euphotides and other resisting rocks thus exposed have been regarded as

eruptive masses of Triassic and Eocene time. The writer, however, holds with Gastaldi that they are indigenous rocks of pre-Cambrian age exposed by geological accidents.

The uncrystalline rocks of the mainland of Italy are chiefly Cenozoic or Mesozoic, and the only Paleozoic strata known are Carboniferous, the organic forms of the limestones of Chaberton having been shown to be Triassic. Triassic, Liassic, Cretaceous, Eocene and Miocene strata are found in different localities resting on the various pre-Cambrian groups. In the Island of Sardinia, however, all these are overlaid by a great body of uncrystalline lower Palæozoic rocks in which the late studies of Bornemann and Meneghini have made known the existence of a lower Cambrian fauna, including Paradoxides, Conocephalites and Archeocyathus, succeeded by an abundant fauna of Upper Cambrian or Ordovician age. In the Island of Elba, according to Lotti, rocks containing the latter fauna repose directly upon the crystalline schists with serpentines.

The existence of the younger or Montalban gneiss in Sweden, and in the Harz and the Erzgebirge was noticed, and to it were referred the Hercynian gneisses and mica-schists of Gumbel. The presence both in Sweden and in Saxony of conglomerates, as described by Hummel, and by Sauer, wherein pebbles of the older gneiss are enclosed in beds of the younger series, was discussed, and the direct unconformable superposition of the latter upon the older gneiss, in the absence of the Huronian, was considered; evidences of the same relations being adduced from the Alps. The gneisses of the St. Gothard, as seen on the Italian slope, were also referred to the newer series, and the important studies of Stapff, in this connection, were discussed. It was declared that the views put forth by the author in 1870-71 on the relations and succession of the crystalline stratified rocks in North America, and then extended by him to Europe, have been fully confirmed by the labors of a great many European geologists, as already shown. Those of Hicks, Hughes, Bonney, Callaway, Lapworth and others in the pre-Cambrian rocks of the British islands were cited in support of these conclusions. It was said that whatever may have been the conditions under which these vast series of crystalline stratified rocks were deposited, there is evidence in the similarity of their mineralogical and geognostical relations of a remarkable uniformity over widely separated regions of the

earth's surface, as well as of long intervals of time, marked by great foldings and disturbance, and by vast and wide-spread erosion of the successive series of rocks.

In conclusion, the writer took occasion to call attention to the important labors of the present school of Italian geologists, and their great zeal, skill and disinterested service, as shown in the memoirs of the R. Academia dei Lincei, and in the work of the Royal Geological Commission, including the special studies, maps and memoirs prepared by it for the International Geological Congress of Bologna in 1881. The new Geological Society of Italy, founded at the same date, gives promise of a brilliant future, and has already published many important memoirs.

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THE ACHENIAL HAIRS OF TOWNSENDIA.

BY PROFESSOR G. MACLOSKIE.

THE genus *Townsendia* of Hooker, belonging to the Asteroid Compositæ, includes about seventeen species, inhabitants of the Rocky Mountain region from New Mexico and Colorado to Eastern California. They are remarkable for the prostrate, hoary habit of most of the species, the linear or spatulate leaves being crowded in rosettes around the rather large flower-heads; the hemispherical or broad campanulate involucre consisting of a few series of imbricating lanceolate bracts with scarious lacerate margins; the plane receptacle; the anthers obtuse at the base; the flattened branches and lanceolate appendages of the styles of the disk-flowers; and most of all for the pappus of the disk-flowers consisting of many (fifteen to thirty) stout bristles, thickened downwards, unequal and scabrid or barbellate. One species (*T. eximia*) has the pappus consisting of two chaff-like bristles arising from a ring of coalescing scales; and in several species the pappus of the ray-flowers is shorter than in the disk, or consists in whole or in part of scales. *T. wilcoxiana* has the pappus very long and fine upwards, but its bristles are thickened or rigid below; and in *T. spatulata* the pappus-bristles are somewhat slender, but their bases are thickened and coalescing into a ring, so that all fall off together. The achenes are flattened with the two angles thickened; sometimes those of the ray-flowers are triquetrous; they are narrow-obovate and more or less pubescent, save in *T. eximia*, where they are broad-ovate and glabrous.